

WATER CONSERVATION BOARD
1313 SHERMAN STREET, ROOM 721
DENVER, CO 80203

DATE: 07-18-12

IMPORTANT

The PO# and Line # must
appear on all invoices,
packing slips, cartons
and correspondence

ACC: 07-17-12



**PURCHASE
ORDER**
STATE OF COLORADO

Buyer: ALLAN SMITH
Phone Number: 303-866-3292
Agency Contact: STEVEN SHULL
Phone Number: 303 866 3441

P.O. # OE PDA 13000000003 Page# 01

State Award #

FEIN 470680568 C Phone: - -

Vendor Contact:

Purchase Requisition #:

V HDR ENGINEERING INC
E HDR INC
N PO BOX 3480
D OMAHA
O NE 68103-0480
R

BID #

Invoice in Triplicate

To: DIVISION OF WATER CONSERVATION
1313 SHERMAN STREET, ROOM 721
DENVER, CO 80203

Payment will be made by this agency

Ship To: DIVISION OF WATER CONSERVATION
1313 SHERMAN STREET, ROOM 721
DENVER, CO 80203

Delivery/Installation Date: 12-31-12
F.O.B. DESTINATION STATE PAYS NO FREIGHT

INSTRUCTIONS TO VENDOR:

1. If for any reason, delivery of this order is delayed beyond the delivery/installation date shown, please notify the agency contact named at the top left. (Right of cancellation is reserved in instances in which timely delivery is not made.)
2. All chemicals, equipment and materials must conform to the standards required by OSHA.
3. NOTE: Additional terms and conditions on reverse side.

SPECIAL INSTRUCTIONS:

LINE ITEM	COMMODITY/ITEM CODE	UNIT OF MEASUREMENT	QUANTITY	UNIT COST	TOTAL ITEM COST
001	91843000000				\$91,722.00
SEV TAX-HDR WILL MODIFY SOFTWARE FOR THE EPAT SYSTEM FOR DWR USES FOR DAM SAFETY ISSUES. PER SOW. CMS#46957.					

THIS PO IS ISSUED IN ACCORDANCE WITH STATE AND FEDERAL REGULATIONS
This PO is effective on the date signed by the authorized individual.

EPSO PAA

DOCUMENT TOTAL =

\$91,722.00

FOR THE STATE OF COLORADO



Authorized Signature

Date

Purchase Order Terms and Conditions

1. Offer/Acceptance. If this purchase order ("PO") refers to vendor's bid or proposal, this PO is an ACCEPTANCE of vendor's OFFER TO SELL in accordance with the terms and conditions of the "solicitation" identified in vendor's bid or proposal. The solicitation includes an RFP, IFB, or any other form of order by buyer. If a bid or proposal is not referenced, this PO is an OFFER TO BUY, subject to vendor's acceptance, demonstrated by vendor's performance or written acceptance of this PO. Any COUNTER-OFFER TO SELL automatically CANCELS this PO, unless a change order is issued by buyer accepting a counter-offer. This PO shall supersede and control over any vendor form(s) or part(s) thereof included in or attached to any bid, proposal, offer, acknowledgment, or otherwise, in the event of inconsistencies or contradictions, regardless of any statement to the contrary in such form(s) or parts thereof. **2. Safety Information.** All chemicals, equipment and materials proposed and/or used in the performance of this PO shall conform to the requirements of the Occupational Safety and Health Act of 1970. Vendor shall furnish all Material Safety Data Sheets (MSDS) for any regulated chemicals, equipment or hazardous materials at the time of delivery.

3. Changes. Vendor shall furnish products and/or services strictly in accordance with the specifications and price set forth for each item. This PO shall not be modified, superseded or otherwise altered, except in writing signed by purchasing agent and accepted by vendor. Each shipment received or service performed shall comply with the terms of this PO, notwithstanding invoice terms or acts of vendor to the contrary, unless this PO has been modified, superseded or otherwise altered in accordance with this section.

4. Delivery. Unless otherwise specified in the solicitation or this PO, delivery shall be FOB destination. Buyer is relying on the promised delivery date, installation, and/or service performance set forth in vendor's bid or proposal as material and basic to buyer's acceptance. If vendor fails to deliver or perform as and when promised, buyer, in its sole discretion, may cancel its order, or any part thereof, without prejudice to its other rights, return all or part of any shipment so made, and charge vendor with any loss or expense sustained as a result of such failure to deliver or perform as promised. Time is of the essence.

5. Intellectual Property. Any software, research, reports, studies, data, photographs, negatives or other documents, drawings or materials (collectively "materials") delivered by vendor in performance of its obligations under this PO shall be the exclusive property of buyer. Ownership rights shall include, but not be limited to, the right to copy, publish, display, transfer, prepare derivative works, or otherwise use the materials. Vendor shall comply with all applicable Cyber Security Policies of the State of Colorado (the "State"), or buyer, as applicable, and all confidentiality and non-disclosure agreements, security controls, and reporting requirements.

6. Quality. Buyer shall be the sole judge in determining "equals" with regard to quality, price and performance. All products delivered shall be newly manufactured and the current model, unless otherwise specified.

7. Warranties. All provisions and remedies of the Colorado Uniform Commercial Code, CRS, Title 4 ("CUCC"), relating to implied and/or express warranties are incorporated herein, in addition to any warranties contained in this PO or the specifications.

8. Inspection and Acceptance. Final acceptance is contingent upon completion of all applicable inspection procedures. If products or services fail to meet any inspection requirements, buyer may exercise all of its rights, including those provided in the CUCC. Buyer shall have the right to inspect services provided under this PO at all reasonable times and places. "Services" as used in this section includes services performed or tangible material produced or delivered in the performance of services. If any of the services do not conform to PO requirements, buyer may require vendor to perform the services again in conformity with PO requirements, without additional payment. When defects in the quality or quantity of service cannot be corrected by re-performance, buyer may (a) require vendor to take necessary action to ensure that future performance conforms to PO requirements and (b) equitably reduce the payment due vendor to reflect the reduced value of the services performed. These remedies do not limit the remedies otherwise available in this PO, at law, or in equity.

9. Cash Discount. The cash discount period will start from the later of the date of receipt of acceptable invoice, or from date of receipt of acceptable products/services at the specified destination by an authorized buyer representative.

10. Taxes. Buyer and the State are exempt from all federal excise taxes under Chapter 32 of the Internal Revenue Code [No. 84-730123K] and from all State and local government sales and use taxes [CRS, Title 39, Article 26, Parts I and II]. Such exemptions apply when materials are purchased for the benefit of State, except that in certain political subdivisions (e.g., City of Denver) vendor may be required to pay sales or use taxes even though the ultimate product or service is provided to buyer. Buyer shall not reimburse such sales or use taxes.

11. Payment. Buyer shall pay vendor for all amounts due within 45 days after receipt of products or services and a correct notice of amount due. Interest on the unpaid balance shall begin to accrue on the 46th day at the rate set forth in CRS §24-30-202(24) until paid in full. Interest shall not accrue if a good faith dispute exists as to buyer's obligation to pay all or a portion of the amount due. Vendor shall invoice buyer separately for interest on delinquent amounts due, referencing the delinquent payment, number of day's interest to be paid, and applicable interest rate.

12. Vendor Offset. [Not Applicable to Inter-governmental POs] Under CRS §24-30-202.4 (3.5), the State Controller may withhold payment under the State's vendor offset intercept system for debts owed to State agencies for: (a) unpaid child support debts or arrearages; (b) unpaid balances of tax, accrued interest, or other charges specified in CRS §39-21-101, et seq.; (c) unpaid loans due to the Student Loan Division of the Department of Higher Education; (d) amounts required to be paid to the Unemployment Compensation Fund; and (e) other unpaid debts owing to the State as a result of final agency determination or judicial action.

13. Assignment and Successors. Vendor shall not assign rights or delegate duties under this PO, or subcontract any part of the performance required under this PO, without the express, written consent of buyer. This PO shall inure to the benefit of and be binding upon vendor and buyer and their respective successors and assigns. Assignment of accounts receivable may be made only upon written notice furnished to buyer.

14. Indemnification. If any article sold or delivered under this PO is covered by a patent, copyright, trademark, or application therefore, vendor shall indemnify and hold harmless buyer from any and all losses, liability, cost, expenses and legal fees incurred on account of any claims, legal actions or judgments arising out of manufacture, sale or use of such article in violation or infringement of rights under such patent, copyright, trademark or application. If this PO is for services, vendor shall indemnify, save, and hold harmless buyer, its employees and agents, against any and all claims, damages, liability and court awards including costs, expenses, and attorney fees and related expenses, incurred as a result of any act or omission by vendor, or its employees, agents, subcontractors or assignees, arising out of or in connection with performance of services under this PO.

15. Independent Contractor. Vendor shall perform its duties hereunder as an independent contractor and not as an employee. Neither vendor nor any agent or employee of vendor shall be deemed to be an agent or employee of buyer. Vendor and its employees and agents are not entitled to unemployment insurance or workers compensation benefits through buyer and buyer shall not pay for or otherwise

provide such coverage for vendor or any of its agents or employees. Unemployment insurance benefits will be available to vendor and its employees and agents only if coverage is made available by vendor or a third party. Vendor shall pay when due all applicable employment, income, and local head taxes incurred pursuant to this PO. Vendor shall not have authorization, express or implied, to bind buyer to any agreement, liability or understanding, except as expressly set forth herein. Vendor shall (a) provide and keep in force workers' compensation and unemployment compensation insurance in the amounts required by law, (b) provide proof thereof when requested by buyer, and (c) be solely responsible for its acts and those of its employees and agents.

16. Communication. All communication concerning administration of this PO, prepared by vendor for buyer's use, shall be furnished solely to purchasing agent.

17. Compliance. Vendor shall strictly comply with all applicable federal and state laws, rules, and regulations in effect or hereafter established, including, without limitation, laws applicable to discrimination and unfair employment practices.

18. Insurance. Vendor shall obtain, and maintain, at all times during the term of this PO, insurance as specified in the solicitation, and provide proof of such coverage as requested by purchasing agent.

19. Termination Prior to Shipment. If vendor has not accepted this PO in writing, buyer may cancel this PO by written or oral notice to vendor prior to shipment of goods or commencement of services.

20. Termination for Cause. (a) If vendor refuses or fails to timely and properly perform any of its obligations under this PO with such diligence as will ensure its completion within the time specified herein, buyer may notify vendor in writing of non-performance and, if not corrected by vendor within the time specified in the notice, terminate vendor's right to proceed with the PO or such part thereof as to which there has been delay or a failure. Vendor shall continue performance of this PO to the extent not terminated and be liable for excess costs incurred by buyer in procuring similar goods or services elsewhere. Payment for completed services performed and accepted shall be at the price set forth in this PO. (b) Buyer may withhold amounts due to vendor as buyer deems necessary to reimburse buyer for excess costs incurred in curing, completing or procuring similar goods and services. (c) If after rejection, revocation, or other termination of vendor's right to proceed under the CUCC or this clause, buyer determines for any reason that vendor was not in default or the delay was excusable, the rights and obligations of buyer and vendor shall be the same as if the notice of termination had been issued pursuant to termination under §21.

21. Termination in Public Interest. Buyer is entering into this PO for the purpose of carrying out the public policy of the State, as determined by its Governor, General Assembly, and Courts. If this PO ceases to further the public policy of the State, buyer, in its sole discretion, may terminate this PO in whole or in part and such termination shall not be deemed to be a breach of buyer's obligations hereunder. This section shall not apply to a termination for vendor's breach, which shall be governed by §20. Buyer shall give written notice of termination to vendor specifying the part of the PO terminated and when termination becomes effective. Upon receipt of notice of termination, vendor shall not incur further obligations except as necessary to mitigate costs of performance. For services or specially manufactured goods, buyer shall pay (a) reasonable settlement expenses, (b) the PO price or rate for supplies and services delivered and accepted, (c) reasonable costs of performance on unaccepted supplies and services, and (d) a reasonable profit for the unaccepted work. For existing goods, buyer shall pay (e) reasonable settlement expenses, (f) the PO price for goods delivered and accepted, (g) reasonable costs incurred in preparation for delivery of the undelivered goods, and (h) a reasonable profit for the preparatory work. Buyer's termination liability under this section shall not exceed the total PO price plus a reasonable cost for settlement expenses. Vendor shall submit a termination proposal and reasonable supporting documentation, and cost and pricing data as required by CRS §24-106-101, upon request of buyer.

22. PO Approval. This PO shall not be valid unless it is executed by purchasing agent. Buyer shall not be responsible or liable for products or services delivered or performed prior to proper execution hereof.

23. Fund Availability. Financial obligations of buyer payable after the current fiscal year are contingent upon funds for that purpose being appropriated, budgeted and otherwise made available. If this PO is funded in whole or in part with federal funds, this PO is subject to and contingent upon the continuing availability of federal funds for the purposes hereof. Buyer represents that it has set aside sufficient funds to make payment for goods delivered in a single installment, in accordance with the terms of this PO.

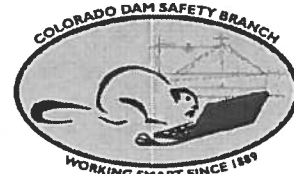
24. Choice of Law. State laws, rules and regulations shall be applied in the interpretation, execution, and enforcement of this PO. The CUCC shall govern this PO in the case of goods unless otherwise agreed in this PO. Any provision included or incorporated herein by reference which conflicts with such laws, rules, and regulations is null and void. Any provision incorporated herein by reference which purports to negate this or any other provision in this PO in whole or in part shall not be valid or enforceable or available in any action at law, whether by way of complaint, defense, or otherwise. Unless otherwise specified in the solicitation or this PO, venue for any judicial or administrative action arising out of or in connection with this PO shall be in Denver, Colorado. Vendor shall exhaust administrative remedies in CRS §24-109-106, prior to commencing any judicial action against buyer.

25. Public Contracts for Services. [Not Applicable to offer, issuance, or sale of securities, investment advisory services, fund management services, sponsored projects, intergovernmental POs, or information technology services or products and services] Vendor certifies, warrants, and agrees that it does not knowingly employ or contract with an illegal alien who will perform work under this PO and will confirm the employment eligibility of all employees who are newly hired for employment in the United States to perform work under this PO, through participation in the E-Verify Program or the Department program established pursuant to CRS §8-17.5-102(5)(c). Vendor shall not knowingly employ or contract with an illegal alien to perform work under this PO or enter into a contract or PO with a subcontractor that fails to certify to vendor that the subcontractor shall not knowingly employ or contract with an illegal alien to perform work under this PO. Vendor shall (a) not knowingly employ or contract with an illegal alien to perform work under this PO, (b) notify subcontractor and buyer within three days if vendor has actual knowledge that subcontractor is employing or contracting with an illegal alien for work under this PO, (c) terminate the subcontract if subcontractor does not stop employing or contracting with the illegal alien within three days of receiving notice, and (d) comply with reasonable requests made in the course of an investigation, undertaken pursuant to CRS §8-17.5-102(5), by the Colorado Department of Labor and Employment. If vendor participates in the Department program, vendor shall deliver to the buyer a written, notarized affirmation that vendor has examined the legal work status of such employee, and shall comply with all of the other requirements of the Department program. If vendor fails to comply with any requirement of this provision or CRS §8-17.5-101 et seq., buyer may terminate this PO for breach and, if so terminated, vendor shall be liable for damages.

26. Public Contracts with Natural Persons. Vendor, if a natural person eighteen (18) years of age or older, hereby swears and affirms under penalty of perjury that he or she (a) is a citizen or otherwise lawfully present in the United States pursuant to federal law, (b) shall comply with the provisions of CRS §24-76.5-101 et seq., and (c) has produced a form of identification required by CRS §24-76.5-103 prior to the date vendor delivers goods or begins performing services under terms of the PO.

3/7/12

**CO Division of Water Resources
Dam Safety Branch**



Scope of Work:

**Extreme Precipitation Analysis Tool (EPAT) Technical Documentation,
Code Debugging & File Preparation to Facilitate 3rd Party Peer Review**

References:

- 1) Hydrometeorological Report No. 55A, Probable Maximum Precipitation Estimates- United States Between the Continental Divide and the 103rd Meridian, E.M. Hansen and D.D. Fenn, Office of Hydrology, National Weather Service, June 1988.
- 2) Hydrometeorological Report No. 52, Application of Probable Maximum Precipitation Estimates – United States East of the 105th Meridian, E.M. Hansen, L.C. Schreiner, and J.F. Miller, Office of Hydrology, National Weather Service, August 1982.
- 3) Hydrometeorological Report No. 49, Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages, E. Marshall Hansen, Francis K. Schwartz, John T. Riedel, Office of Hydrology, National Weather Service, Reprinted 1984.
- 4) McKee, Thomas B. and Nolan J. Doesken, "Colorado Extreme Storm Precipitation Data Study", Climatology Report #97-1, Colorado State University Department of Atmospheric Sciences, May 1997.
- 5) Extreme Precipitation Analysis Tool – EPAT [User's Manual], HDR Engineering, Inc., January 16, 2008.
- 6) Rahrs, Rob; John Henz, Bill McCormick, Jason Ward, and John G. Blair, "Colorado Extreme Precipitation Analysis Tool: Need, Evolution, Development and Application", ASDSO Proceedings, Dam Safety 2008, Indian Wells, CA, September 7-11, 2008
- 7) Hydrometeorological Report No. 50, Meteorology of Important Rainstorms in the Colorado River and Great Basin Drainages, Francis K. Schwartz, E. Marshall Hansen, Office of Hydrology, National Weather Service, December 1981.

Purpose:

Technical documentation (including data, processes and visual basic code), and code debugging. Results of project are intended to facilitate a 3rd party peer review of the Extreme Precipitation Analysis Tool (EPAT) v4.2.

Background:

The software was developed by HDR Engineering, Inc. (HDR) under contract with Colorado Division of Water Resources, Dam Safety Branch, in order to develop modern meteorological techniques for evaluating the safe spillway size for High and Significant Hazard dams. Development of the program began for Colorado's West Slope, the region also covered by HMR 49. The West Slope version of the program was released in September 2006. Later versions of EPAT were released for the entire State, excluding areas below 5,500 feet in elevation east of the Continental Divide (Reference 6, p. 7), and with a basin area upper limit of 500 square miles. The Dam Safety Branch believes that the program was more thoroughly tested for the West Slope than for areas east of the Continental Divide. Much of the data and procedures in EPAT are based on NOAA Hydro Meteorological Reports (HMRs) and CSU report 97-1

(Reference 4), but with deviations in some cases. Minimal documentation was provided to the Dam Safety Branch (Reference 5); we have no technical software documentation. After several years of use, the Dam Safety Branch has identified areas of concern with EPAT results, especially in areas along Colorado's Front Range, the region covered by HMR55A. Finally, EPAT has not been peer reviewed by the hydro-meteorological community; typically dam safety regulatory agencies require Site Specific Hydro-Meteorological Studies to be peer reviewed. As such, given that EPAT is a 'site-specific' tool for precipitation analysis, an independent peer-review of the tool is deemed important to solidifying confidence in EPAT for its intended purpose.

Program Code:

Code is written in VisualBasic.net. EPAT requires installation of ESRI ArcMap 9.1 with the Spatial Analyst Extension and ESRI .net components (Reference 5).

Timeline:

Work is anticipated to start on or around July 15, 2012. Ninety (90) percent drafts of all deliverable reports are to be submitted to the Dam Safety Branch no later than November 15, 2012, for review and comment. Comments will be returned within 14-days of receipt. All work and final deliverables are to be completed no later than January 15, 2013.

Scope of Work: This Scope of Work consists of the following three Tasks along with sub-tasks.

Task 1. Software and Technical Documentation: Using the EPAT source code, information from the Colorado Dam Safety Branch staff and information from the project files residing at HDR Engineering and any other applicable sources, develop and provide software documentation in accordance with industry standards so that the program is transparent to end users. The results of this task will be utilized to facilitate educated use of the program and its output, peer review, code maintenance, de-bugging, and future modifications.

- a) The following general documentation shall be performed:
 - i) Software Architecture Documentation
 - (1) Data flow diagram including all decision points
 - (2) Relational database schema
 - (3) Database metadata
 - ii) Software Technical Documentation
 - (1) Provide documentation of explanatory notes in the code
 - (2) Document all variables, equations, and algorithms used in the code
- b) **In addition**, the documentation shall specifically describe all processes and features of EPAT including, but not limited to the following:
 - i) EPAT Storm Database: define each database field and document the source of data to the best extent possible.
 - ii) Climate Zones:
 - (1) Document the meteorological basis of the EPAT Climate Zones and boundaries, which are a fundamental feature of EPAT. EPAT Climate Zones depart from those shown in CSU Report #97-1 (Reference 4). Reference 6 (p. 4) describes the CSU report as the basis for the EPAT Climate Zones, but there have been changes in the Zones as EPAT has evolved.
 - (2) Document where Climate Zone boundaries are based on physical topographic barriers to storm transposition as opposed to where boundaries might be based on inexact transition zones (for example, the 7500 foot elevation contour along the Front Range).
 - (3) Document the significance of EPAT Climate Zone sub-divisions, e.g., Zone 4a, 4b, 4c, 4d, and 4e, and why those have changed as EPAT has evolved.
 - (4) Document the meteorological basis for including the Upper Arkansas River Basin in Climate 6b (predominantly west slope) and 4d (predominantly Wet Mountain foothills).
 - iii) Storm Selection and Areal Attribution:
 - (1) To the extent that EPAT Climate Zones are used to identify like climatological regions and dictate storm selection for a given basin, provide documentation on how the Climate Zone database is accessed and attributed to a basin.
 - (2) Document the scientific methodology used by HDR to determine the transposition limits for each historic extreme storm in EPAT. Recognizing that meteorologists may disagree on appropriate transposition limits for a given storm, document to the level needed to facilitate a 3rd party peer review, relevant climate and meteorological properties of each storm and how they were used by HDR to develop transposition limits in EPAT. Documentation describing how transposition limits were determined for each historic storm shall be included in Task 1 Deliverables, sub-item (e).
 - (3) Document the methodology by which EPAT determines what Climate Zone a drainage basin is located in (i.e., a drainage basin of interest may cover multiple EPAT Climate Zones and experience has shown that the Climate Zone/storm selection is sensitive to adjustments in the EPAT Basin Track).

- iv) General and Local Storm Classification:
 - (1) Document the meteorological basis for assigning *Local* and *General* storm classifications for each storm in the EPAT storm library and why those classifications differ from those used by the HMRs in many cases (e.g. the 1921 Pueblo\Penrose storm, the 1935 Cherry Creek storm, and the 1965 Plum Creek storm).
 - (2) Document where the Storm Classifications are stored within the database, and how these classifications are used by EPAT in the calculations.
- v) Storm Climatology: Create a summary sheet(s) for each storm in the EPAT storm library with a map showing the original storm isohyets in the original storm location, relevant original storm meteorological and geographic data, data relevant for storm maximization, the storm's temporal distribution, the EPAT Climate Zone in which the storm originally occurred, a graphical representation of the storm's transposition limits in EPAT, and the meteorological basis/rationale for the storm's transposition limits in EPAT.
- vi) In-Place Storm Maximization:
 - (1) Document the procedures and data utilized for the in-place maximization step for each storm in EPAT prior to placement in a basin for assessment. This documentation should utilize the same terminology and variables utilized in the HMRs where possible.
 - (2) Verify the validity of in-place and seasonal maximization equations shown in References 5 (pp. 18-21) and 6 (pp. 14-15), and likewise check equations used in the EPAT code.
 - (3) Document the representative storm dew point (i.e., $PW_{I_{STORM}}$ in References 5 & 6) and the seasonally adjusted maximum persisting 12-hour dew point (i.e., $PW_{I_{SEASONAL MAX}}$ in References 5 & 6) for each extreme storm in EPAT and document the data source. Document at what location the dew point was determined, e.g., was it determined at the storm center or at a point along the moisture supply route as in HMR55A (p. 83-84).
 - (4) Explain the rationale behind EPAT's simplified maximization procedure (see Reference 5, pp. 18-21) relative to HMR55A's fairly complex "Storm Separation Method" of separating convergence and orographic precipitation prior to maximization (see HMR55A Chapters 6 & 7). The EPAT maximization procedure appears to be similar to that used for Local Storms in HMR55A (Chapter 12, p. 194). This discussion should also explain differences in General versus Local storm classifications in EPAT (see sub-task iv) compared to the HMRs and the resulting differences in maximization procedures.
 - (5) Document whether the original (versus in-place maximized) extreme storm data reside in the EPAT databases or only maximized data. The Dam Safety Branch is not clear whether precipitation isohyets in the EPAT rainfall shapefile are original storm or in-place maximized values. Our understanding is that in-place storm maximization only needs to occur one time for a given storm. Reference 5 (pp. 20-21) indicates that maximization was "hard coded" and was done during the development stage of the EPAT Storm Library.
- vii) Storm Transposition:
 - (1) Document transposition methodology and GIS manipulation (see Reference 5, pp. 21-22; Reference 6, p. 16). This documentation should utilize the same terminology and variables utilized in the HMRs where possible.
 - (2) Document whether PWI values used in EPAT for the original and transposed

storm locations are consistent with each other and consistent with the method used in the HMRs. HMR55A (pg. 132) states that "in each case [the original and transposed locations] the dew point is selected at the same distance and direction from the point as the representative storm dew point." In HMR55A, the "representative storm dew point" was typically determined at some distance upwind of the storm that was not influenced by precipitation (HMR55A, p. 83). For example, in HMR55A representative and maximum storm dew points for the 1921 Penrose, CO, storm were determined at Amarillo, TX, and Oklahoma City, OK. The Dam Safety Branch has a concern that the GIS manipulation in EPAT may compare the PWI value from the PWI raster file at the exact transposed storm location with either the PWI raster value at the exact original storm location, which may be inconsistent with the HMR55A procedure, or that EPAT compares the PWI raster value at the transposed storm location with the HMR PWI value, which may not be analogous.

viii) Storm Orientation:

- (1) Document the GIS manipulation of the storm orientation within a basin.
- (2) Document the meteorological basis for orienting storms based on the general orientation of the drainage basin as defined by the Basin Track shapefile. Reference 6 (p. 5) describes a 2003 Feasibility Report and a 2005 Expanded Study by John Henz as the basis for orienting storms in this manner. Please document any other published meteorological literature that supports this approach and was used to develop the EPAT storm orientation method.
- (3) Document whether EPAT adjusts the original rainfall amount when the transposed storm orientation differs from the orientation of the original storm. The Dam Safety Branch has a concern that a transposed storm in EPAT may be oriented on an azimuth significantly different than that of the original storm orientation and original moisture supply route. Please reference the method used in HMR 52 to adjust rainfall where a transposed storm orientation differs from that of historic storms at a geographic location.

ix) Elevation Adjustment:

- (1) Document elevation adjustment methodology and equations for transposed storms with an analyzed two-dimensional footprint (see Reference 5, p. 27; Reference 6, p. 19). This documentation should utilize the same terminology and variables utilized in the HMRs where possible.
- (2) Document whether the elevation adjustment varies with each storm placement along the basin track or whether the adjustment is based on static basin properties (e.g. single point at the mean basin elevation).
- (3) Document the meteorological basis for the 9%/1000-ft adjustment applied in EPAT and address departures from HMR49 and HMR55A procedures. Please note that HMR55A applies only one-half of the potential barrier elevation reduction in PWI in the case of General Storms (see HMR55A, p. 133).
- (4) Document how the elevation adjustment is applied to point storms, specifically describe at what location in the basin the point storm is assumed to be centered.

x) Point Storm Application and Two-Dimensional storm footprint development:

- (1) Document depth-area-duration (D-A-D) factors applied to point-value storms, the regions where different factors are applied, and, the source of the factors and associated regions.
- (2) Document GIS methodology and algorithms for applying areal reduction to point-value storms.

- (3) Document the data utilized and the methodology employed in determining the two-dimensional pattern of storms with a defined spatial footprint.
- xi) Temporal Distribution:
 - (1) Document the source of the temporal distribution used for each storm in EPAT.
 - (2) Document where temporal storm data are stored and how the data are used by EPAT. This will include documentation of storm mass curves for each storm as part of the Appendix for the technical report.
- xii) Basin Track & Number of Runs:
 - (1) Document how EPAT uses the basin track and the number of runs in storm selection, storm placement, storm transposition, storm elevation adjustments (etc.). Specifically address whether storm transposition, storm elevation adjustments, and climate zone attribution/storm selection vary with each 'run' location along the basin track OR whether they are based on static basin properties (e.g. basin centroid, mean basin elevation, etc.).
 - (2) Are the basin track and number of runs used by EPAT in the analysis of "point storms"?
- xiii) Output: Document the algorithm and rationale that EPAT uses to list relevant (i.e. rank) storms in the output.
- xiv) Storm Library Modifications: The EPAT storm library was intended to be a living database, where new extreme storms would be added after they are analyzed.
 - (1) Document the recommended documentation/analysis procedures and programming procedures required for adding and implementing new storm data to EPAT.
 - (2) Document the criteria that were used by HDR to include a historic storm in the EPAT v4.2 storm library.
- xv) ESRI ArcMap Compatibility: A limitation of EPAT v4.2 is that it requires ESRI ArcMap 9.1 with the Spatial Analyst extension; EPAT will not run in newer versions of ArcMap. Document the programming required to upgrade EPAT to run in both ArcMap 10 and ArcServer.
- xvi) EPAT is currently limited to drainage basins less than or equal to 500 square miles. Discuss the reasons for this limitation and whether the program could be modified to allow larger storms.

Task 2. Program debugging: The Dam Safety Branch has identified the following concerns with EPAT results that shall be reviewed to determine if there are errors in the EPAT code (the Dam Safety Branch will provide example drainage basin and basin track shapefiles that reproduce concerns i and ii). Results shall be documented. If errors are found they shall be presented to the Dam Safety Branch and a method for correcting the error should be recommended. Likewise any and all problems with the code, source data, database and methodology encountered during the execution of this scope must be documented and described.

- i) Check D-A-D factors and associated regions applied to point storms. Based on Dam Safety Branch investigations it appears that EPAT applies HMR55A General Storm aerial reduction factors to EPAT Local Storms and uses regions that are inconsistent with HMR55A D-A-D Terrain Regions.
- ii) Check the storm selection algorithm. The Dam Safety Branch has concerns that EPAT's storm selection procedure is sensitive to minor changes in the alignment of the basin track. Explain why the storm selection for a drainage basin can change (i.e. an entirely different set of storms can be selected by EPAT) based solely on a

minor change of the basin track.

- iii) Check transposition limits assigned to each storm; the Dam Safety Branch has found that some storms are not selected in the same drainage basin in which at least part of the storm occurred. For example part of the 1965 Plum Creek Storm (EPAT StormID 47) occurred in Climate Zone 4a on the northwest slope of Pikes Peak, where several dams failed as a result. EPAT does not include Climate Zone 4a in the transposition limits of the 1965 Plum Creek storm.
- iv) Check temporal distribution data for errors. It has been observed that there is erroneous data in some distributions (e.g. El Paso/Pueblo Storm, StormID 58).
- v) EPAT frequently crashes upon generating output files. Check for problems in output routine.

Task 3. Preparation of EPAT code & HDR EPAT Files to Facilitate 3rd Party Quality Control Review of EPAT code and Meteorological data & 3rd Party Scientific Peer Review of

EPAT: HDR indicated to the Dam Safety Branch that much of the rationale, analysis, computations, meteorological judgment, etc. performed in the course of developing the EPAT program, its Climate Zones, and its Storm Library, are in a state that would be difficult for a 3rd party to peer review. As described in the Background section of this Scope of Work, peer review is necessary for EPAT to be widely-accepted and defensible. Much of the necessary documentation for a 3rd party review will be provided in Task 1 of this Scope of Work. Task 3 involves any additional work required by HDR to prepare the EPAT code and HDR EPAT files in order to facilitate a QC Review and Scientific Peer Review. Task 3 shall include, but not be limited to, the following:

- i) Provide explanatory comments in the EPAT computer code for all routines, sub-routines, equations, algorithms, logic statements, and all significant lines of computer code in order to facilitate 3rd party review of the code.
- ii) Provide copies of all HDR Engineering EPAT files necessary to facilitate a 3rd Party Quality Control Review of the code and all data in EPAT and to facilitate a 3rd Party Scientific Peer Review of EPAT.

Meetings & Reviews:

Progress meetings will be conducted with representatives of the Dam Safety Branch at the 60 percent and 90 percent completion stage for each Task in the Scope of Work. The Dam Safety Branch will provide review comments after each progress meeting.

Ninety (90) percent complete versions of each deliverable shall be provided to the Dam Safety Branch for review and comment. Review comments will be provided by the Dam Safety Branch, and comments shall be addressed satisfactorily before the final deliverables are accepted.

Deliverables:

Task 1 Deliverables: Technical Documentation Report: Results of Architecture and Technical Documentation defined in Task 1 in the Scope of Work (10 hard copies and electronic pdf file). The report shall satisfactorily address all tasks and sub-tasks under Task 1 of the Scope of Work, and shall include but not be limited to the following:

- a) Documentation of storm selection, storm assignment and database development

- b) Documentation of the methodology behind each analysis step performed for a given storm analyzed in a basin, including a complete demonstration of the calculations for one example storm in the database.
- c) Documentation on final post-analysis EPAT output for user review including data and methodology.
- d) Appendix with full storm database information including data sources and methodologies employed to fully populate each storm database element.
- e) Summary sheet for each storm in the EPAT storm library with a map showing the original storm isohyets in the original storm location, relevant original storm meteorological and geographic data, data relevant for storm maximization, the storm's temporal distribution, the EPAT climate zone in which the storm originally occurred, graphical representation of the storm's transposition limits in EPAT, and the meteorological basis/rationale for the storm's EPAT transposition limits.

Task 2 Deliverables: Debugging Documentation Report: The report shall document the explanation for each of the Dam Safety Branch concerns with EPAT performance enumerated in Task 2 of the Scope of Work. The report shall document whether Dam Safety Branch concerns are the result of errors in the EPAT code, and if so the error shall be documented. Likewise any and all problems with the code, source data, database and methodology encountered during the execution of this scope must be documented and described. Recommendations for repairs to the code/data shall be documented in the report. Provide 10 hard copies and electronic pdf file.

Task 3 Deliverables: Preparation of HDR EPAT files and EPAT code to facilitate 3rd party QC Review of the code and meteorological data, and Scientific Peer Review of the EPAT program. Deliverables shall include:

- a) An executable electronic copy of the EPAT VB.net computer code, with explanatory notations as described in Task 3 of the Scope of Work.
- b) One hard copy and one electronic copy (pdf file format) of all HDR Engineering files necessary to facilitate Quality Control Review of the code and meteorological data and a 3rd party peer review of the EPAT program. Files may include computations, maps, references, internal documentation, meeting minutes, phone conversation records, records of communication with other experts, computer files, radar data, or any other supporting documentation that was used by HDR to develop the EPAT program, EPAT Climate Zones, the EPAT Storm Library, In-place Maximized Storm Data, Storm Transposition Limits, and all Climate Data for each Extreme Storm.

STATE OF COLORADO

Colorado Water Conservation Board Department of Natural Resources

1580 Logan Street, Suite 600
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John W. Hickenlooper
Governor

Mike King
DNR Executive Director

Jennifer L. Gimbel
CWCB Director

July 20, 2012

Mr. William McCormick, P. E., P. G.
Chief, Dam Safety Branch
Division of Water Resources
7405 Highway 50
Salida, CO 81201

Dear Mr. McCormick:

This refers to your application for funding from the Severance Tax Trust Fund Operational Account (STOA) for the year commencing July 1, 2012. The Colorado Water Conservation Board (CWCB) has approved your application for funding in an amount up to \$100,000 to complete your project for "Extreme Precipitation Analysis Tool Software (EPAT) Verification." Funds are available now and work should be completed by June 15, 2013. Funds should be disbursed to you by June 30, 2013. Please contact Mr. Kirk Russell at Telephone No. (303) 866-3441, ext. 3232, to assist you through the process.

Should you have any questions or if I can be of any further assistance, please contact me at Telephone No. (303) 866-3441, ext. 3205.

Very truly yours,

S. S. Biondo
Finance Manager

HANNA - YOUR COPY

cc: ~~Mr. Kirk Russell, P. E., CWCB Chief~~
CWCB Files

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SEVERANCE TAX TRUST FUND OPERATIONAL ACCOUNT

FINANCE

PROPOSED PROJECT FY 12/13

John W. Hickenlooper
Governor

Mike King
DNR Executive Director

Jennifer L. Gimbel
CWCB Director

Staff Lead: Kirk Russell

Recommended Amount: \$100,000

Requested Amount: \$150,000

Title of Project: Extreme Precipitation Analysis Tool (EPAT) Software Verification Project

Description of Project:

Software documentation, quality control testing, and scientific peer review of EPAT v4.2.

The software was developed by HDR Consultants under contract with DWR, in order to develop modern meteorological techniques for evaluating the safe spillway size for High and Significant Hazard dams. The West Slope version of the program was released in September 2006. Later EPAT was released for the entire State, excluding areas below 5,500 feet in elevation east of the Continental Divide, and with a basin area upper limit of 500 square miles. Dam Safety Branch staff feels that the program was more thoroughly tested for the West Slope than for other areas. Only minimal documentation was provided and no technical software documentation was provided. After several years of use, DWR staff has identified areas of concern with EPAT results, especially in areas along Colorado's Front Range. Also, EPAT has not been peer reviewed by the meteorological community; typically dam safety regulatory agencies require Site Specific Hydro-Meteorological Studies to be peer reviewed.

Software Documentation: provide software documentation in accordance with industry standards, for example Software Development Life Cycle (SLDC) process, so that the program is transparent to end users and is not regarded as a "black box".

Quality Control Testing: Using the documentation created in Task 1) and the EPAT source code, thoroughly test the code, database relationships, and database data for errors.

Scientific Peer Review: Review all data, procedures, methods, algorithms, and code and evaluate whether they are meteorologically sound, reasonable, and defensible based on modern meteorological techniques

Project Manager(s): Anna Mauss

Program: Water Project Loan Program

Purpose: This project will help DWR and in turn be a valuable tool for the CWCB Water Project Loan Program users.

Funding Available: July 1, 2012 – June 30, 2013